Space Weather Technical Forecast

Issued on Wednesday, 19 July 2023 at 01:14 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Minor/Moderate R1/R2 Blackouts likely throughout. Chance of G1/G2 (Minor/Moderate Storms) during 20 July.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity was Moderate, with several M-class flares observed. The largest was a long duration M5.7 peaking at 18/0006 UTC and originating from AR3363 in the southwest quadrant, near the horizon. Another long duration flare was observed later in the day peaking at M2.1 at 18/2027 UTC, again from the same source. There are currently ten sunspot regions on the visible disc. A number of large groupings are evident in the northern hemisphere, and three of these are notably close to centre disc. A significant asymmetric halo CME (Coronal Mass Ejection) was observed leaving the Sun from the southwest limb, related to the flare and this appears to have an Earth-bound component. The second significant M-class flare, late in the day, has also potentially given another CME and this will be analysed in the coming hours.

Solar Wind / Geomagnetic Activity: The solar wind parameters are indicative of the waning influence of a magnetic cloud associated with a CME that arrived on the 16th. The solar wind started the period at elevated levels around 550km/s and is now on the decline, currently at slightly elevated levels around 460km/s. Density was mostly around average. The total magnetic field (IMF), Bt, has been weak and mostly below 7nT. The north-south component fluctuated between +5 and -6nT and remains weak and is now mostly orientated northward. Phi angle was consistently negative (towards the Sun). This resulting in Quiet to Unsettled (Kp1-3) geomagnetic activity, with some Active (Kp4) intervals observed.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV), as observed by GOES16, climbed to Moderate S2 levels shortly after the long duration flare emitted by AR3363. The flux rose above the S2 threshold after 18/0200 UTC, reaching a peak of 620pfu at 18/0615 UTC. Levels are now declining towards S1 levels. High energy electron flux (greater than 2MeV) started at background levels and rose to moderate levels by 18/1000 UTC, with a peak of 936pfu observed at 18/1720 UTC. The 24-hour integrated fluence responded with a corresponding increase and remains below the Active (1e8 integrated pfu) threshold. A fluence of 2.35e7 pfu was recorded at 18/2100 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to remain Moderate, with occasional M-class flares and a slight chance of an isolated X-class flare, and this is most likely to originate from the largest sunspot grouping which is AR3373, located in the northeast.

Solar Wind / Geomagnetic Activity: Current CME influence is expected to gradually ease during day 1 (19 July). A high speed stream (HSS) may connect with Earth but this is most likely to be masked by the already elevated solar winds. Another CME was observed leaving the sun after the M5.7 flare that occurred on 18/0000UTC. This will probably affect Earth early on Day 2 (20 July) with effects continuing into the day 3 (21 July). Geomagnetic activity is therefore expected to be Quiet to Unsettled on day1 (19

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July) with a chance of an active interval, then there is an increasing probability of G1/G2 (Minor/Moderate) storms intervals on day 2 (20 July). Activity returning to Quiet (Kp1-2) with a chance of Unsettled (Kp3) intervals by day 4 (22 July) as CME effects wane, but confidence is low as it largely depends on the arrival time of the CME.

Energetic Particles / Solar Radiation: High energy electron flux (greater than 2MeV) is expected to remain moderate on day 1 but may exceed high levels during the diurnal peak. The electron flux may remain Low or Moderate on day 2 under the influence of the expected CME before becoming High again by day 4, perhaps leading the fluence to breach the Active threshold (1e8 integrated pfu). The high energy (greater than 10MeV) proton flux is currently above the minor storm (S1) threshold level. Further (new) solar radiation storms are possible early in the guidance period, especially if the large region in the southwest quadrant emit another large flare. This risk declines over the following days as this region rotates onto the far side. Currently the ongoing minor solar radiation storm will probably continue for much of the guidance period, especially if another significant proton rich flare is emitted.

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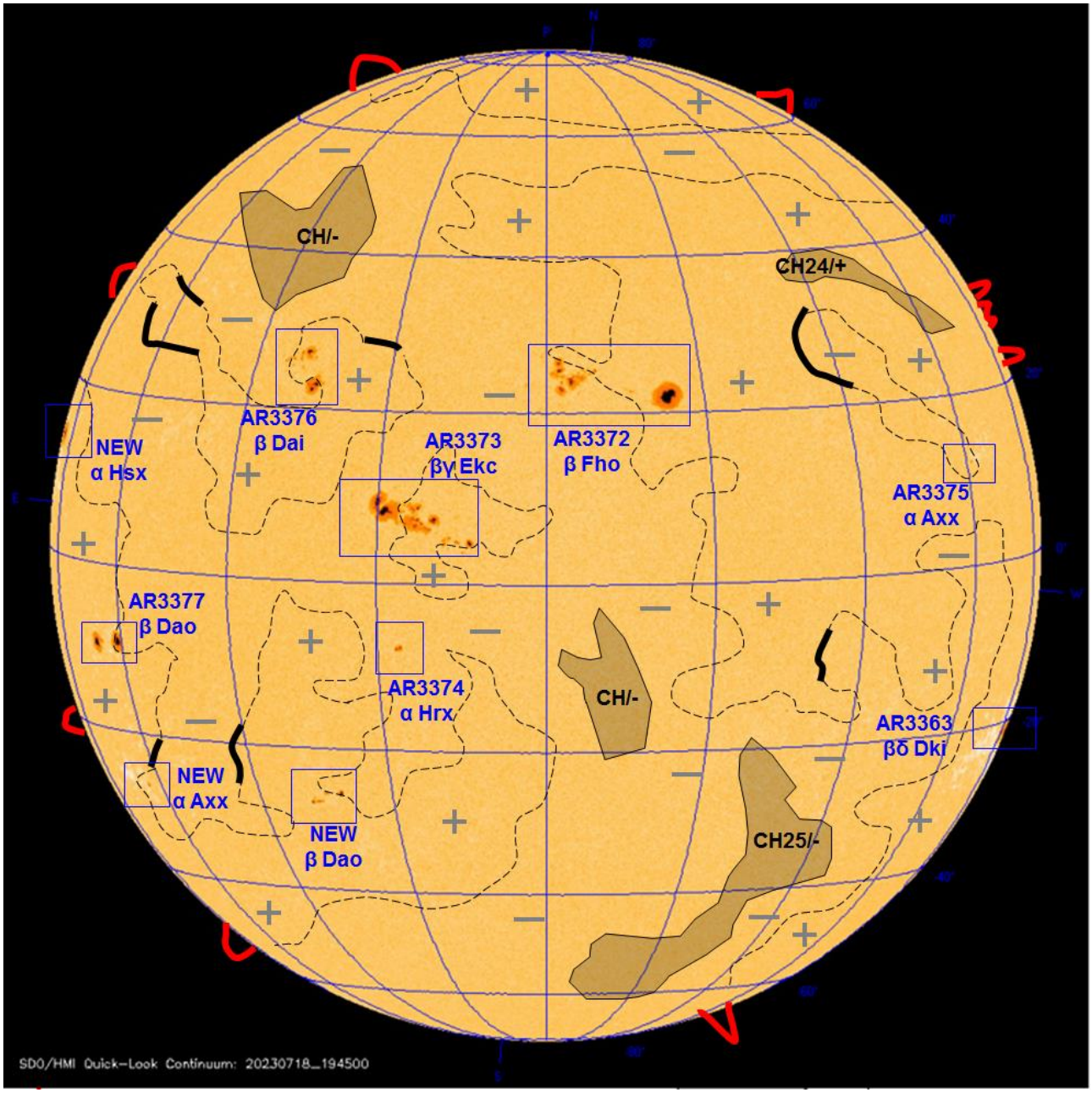
Figure 1. Solar Analysis Valid 2000UTC, 18 July 2023.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

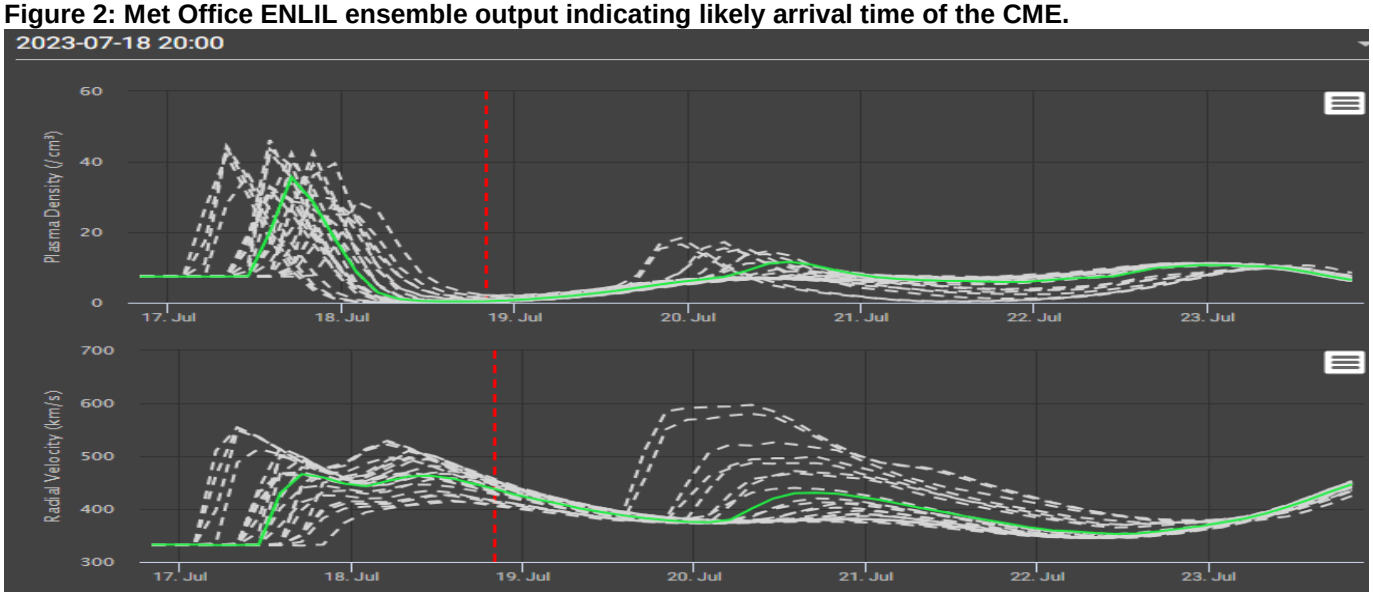
Solar winds are slightly elevated and declining towards slow-ambient levels, under the waning influence of the magnetic cloud associated with the CME that arrived late on 16 July. The CME observed following the M5.7 flare that occurred around 18/0000 UTC has been analysed as potentially giving Earth a blow on the 20th (Day 2), with effects probably continuing into the 21st (Day 3). The high speed stream from CH24 may connect with Earth during the next 24 hours but is a small feature, with limited enhancements which may be masked by the continuing CME effects. Geomagnetic activity is therefore expected to be Quiet to Unsettled on day 1 (19th) with a chance of an active interval, especially early in the day. Activity then probably becoming Active with a chance of G1/G2 (Minor/Moderate) storms intervals on day 2 (20th). Activity returning to Quiet with a chance of Unsettled intervals by day 4 (22nd) as CME effects wane, but confidence is low as it will largely depends on the arrival time of the CME.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	5	50	10	1
Strong	G3	No	1	10	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
18/0145 UTC	Asymmetric full	M4.7 from AR3363	SW quadrant near limb	1638 km/s	20/0600 UTC +/- 6hrs	Bulk of ejecta passing south of Earth

Figure 2: Met Office ENLIL ensemble output indicating likely arrival time of the CME.



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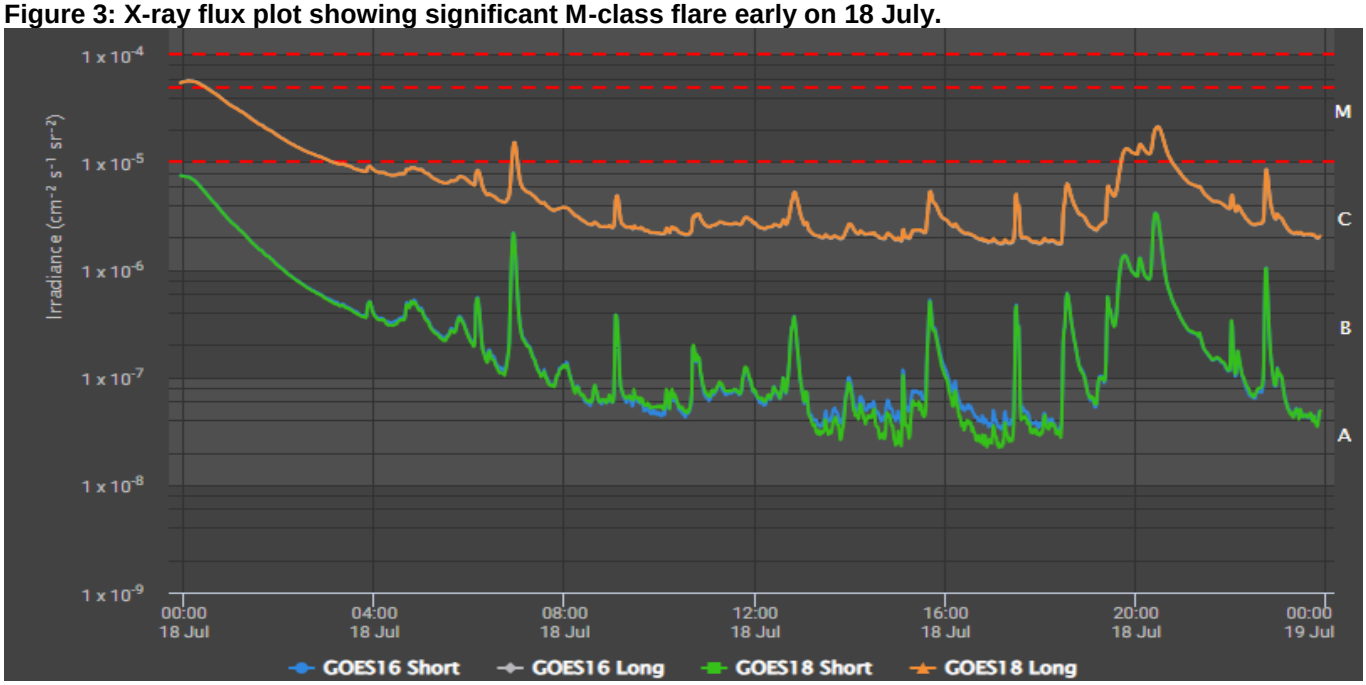
Radio Blackouts - X-Ray Flares:

Solar activity remains at Moderate levels, with several M-class flares observed. The largest was a long duration M5.7 peaking at 18/0005 UTC from AR3363. There are currently ten sunspot regions on the visible disc. AR3363 is on the western horizon and probably remains complex and unstable. AR3372 is a large open region, consisting of a simple symmetric leader and a more complex broken trailer that includes occasional, small delta spots. AR3373 remains large and complex. AR3376 in the northeast displays further penumbra development, especially in the leader spot. It is also north-south magnetically aligned. AR3377 near the southeast limb consists of two large spots and appears stable. A new unnumbered region in the southeast quadrant, has developed further with spot emergence and penumbra in the leader and trailing spots .A large sunspot in the northwest is emerging over the northwest limb. Remaining regions appear stable and relatively small. Solar activity is Moderate, with the largest M-class flare observed being a notable long duration M5.7 peaking at 18/0005 UTC from AR3363. This may have been triggered by a filament eruption that occurred just prior to the eruption. The combined eruptions generated a solar storm with levels now dipping back to S1 levels. Further M-flares remain likely with Moderate activity continuing. The chance of an isolated X-class flare is slightly higher than statistically generated raw probabilities following recent flaring events, with AR3373 (in the northeast) being the most likely candidate.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	80	70	70	70
Very Active	R3 to R5 X Class	No	20	15	15	15

Figure 3: X-ray flux plot showing significant M-class flare early on 18 July.



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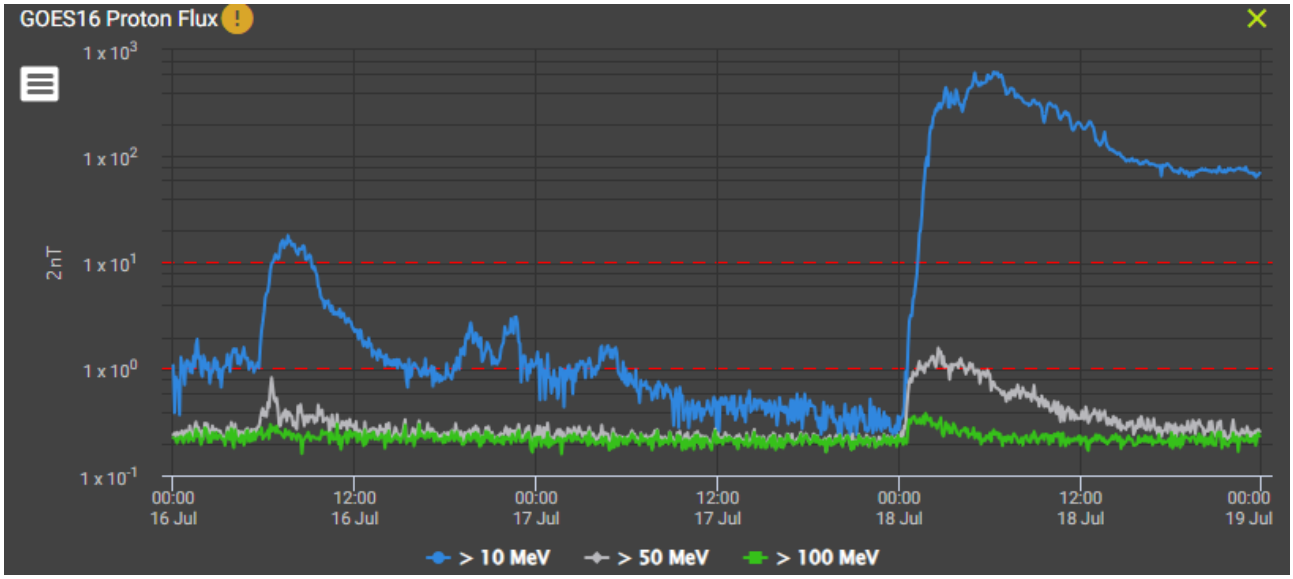
Solar Radiation Storms - (High Energy Protons):
The high energy (greater than 10MeV) proton flux is currently above the minor storm (S1) threshold level. Further (new) solar radiation storms are possible early in the guidance period, especially if the large region in the southwest quadrant emit another large flare. This risk declines over the following days as this region rotates onto the far side. Currently the ongoing minor solar radiation storm will probably continue for much of the guidance period, especially if another significant proton rich flare is emitted. The two active region candidates most likely to contribute to further solar radiation storms are AR3373 in the northeast, and approaching centre disc and secondly AR3363 which is now rotating over the southwestern horizon onto the far side in coming hours. Its position will continue to offer a significant risk. As well as this further large regions are poised to rotate onto the visible side of the solar disc, maintaining the risk of further solar radiation storms through much of the guidance period.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	100	80	60	50
Very Active	**≥ S3 ***	No	10	5	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: Proton flux plot at GEO showing ongoing radiation storm.



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High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) has risen to moderate levels in the past 24 hours following the CME that arrived on the 16th, the associated magnetic cloud progressively charging the radiation belts. A further diurnal rise is expected to be relatively modest on day 1 but may exceed high levels during the diurnal peak. The denser and stronger winds associated with the CME expected to give Earth a blow on day 2 (20th) may reduce temporarily the electron flux but these should replenish the radiation belts by day 4 (22nd) , leading the fluence to potentially breach the Active threshold (1e8 integrated pfu). Low confidence in the timing of this scenario though. The latest Met Office REFM output is in reasonable agreement although it is thought to under-estimate the impacts of the coming CME.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	40	20	30	60
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	20

Figure 5: High energy electron flux at GEO from GOES and Met Office REFM output.

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